

Applying NeuralODE-based Cardiovascular Model Identification for Experimental Data Analysis

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Abstract—Recent model-based diagnostic methods have been found promising to provide non-invasive perfusion markers to assess the efficacy of fluid therapy, the most common treatment method for acute circulatory failure (ACF). The development of these model-based diagnostic methods requires the identification of the central arterial pressure curve based on the femoral arterial pressure. This current study presents improvements of the previously suggested NeuralODE-based identification method by suggesting the use of a physiologically interpretable parameter set of the Tube-load model-based transfer function for the physiological system analysis and suggesting a calculation method decreasing the measurement error-caused uncertainty of the identification parameter, called pulse transfer time.

Index Terms—model-based medical therapy, cardiovascular diagnostics, physiological system modelling, parameter identification, transfer function, Neural ODE, intensive care, personalized medical therapy

I. INTRODUCTION

In the case of Acute Circulatory Failure (ACF), fluid therapy is a widely used intervention to stabilize heart function [1]. However, the effectiveness of fluid therapy is not directly predictable, and the therapy can also be harmful. Physiological models can predict fluid responsiveness - describing the effectiveness of fluid therapy for the patient -, but aortic (central arterial) blood pressure must be used to identify their parameters [2]–[5]. The measurement of central arterial

blood pressure is highly invasive and uncommon in clinical practice. However, the aortic pressure can be approximated using femoral arterial pressure measurements ([6], [7]). The Tube-load model [8], [9] describes the relationship between the femoral and central arterial blood pressures if the correct parameters of the model are known for the current patient. In our previous study, a NeuralODE-based parameter identification method for the transfer function parameters was suggested [10]. By identifying the transfer function parameters for a given physiological measurement, the parameter values can be examined, and their connection to different physiological states can be defined.

The aims of the current study are twofold. At first, two system parameters derived from the transfer function parameters are proposed that are more appropriate for describing the patient's blood vessels' state. The second objective is to suggest a calculation method that decreases the measurement error-caused uncertainty of the identification parameter, called pulse transfer time.

II. METHODS AND DATA

A. Experimental Data Set

The experimental data set used in this study was collected from a series of animal experiments performed at the Central Hospital of the University of Liege (Reference Number 14-1726). In the experiments, a cohort of 7 pure Piétrain pigs. The pigs underwent different haemodynamic interventions during the measurements. During mechanical ventilation for every pig, a number of respiratory recruitment manoeuvres were performed in which positive end-expiratory pressure (PEEP)

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is increased in steps of 5 cmH₂O. Increasing positive end-expiratory pressure reduces systemic venous return to the right heart and increases pulmonary resistance. The schedule of these interventions is shown in Figure 1. Further details of the data collection can be found in [10].

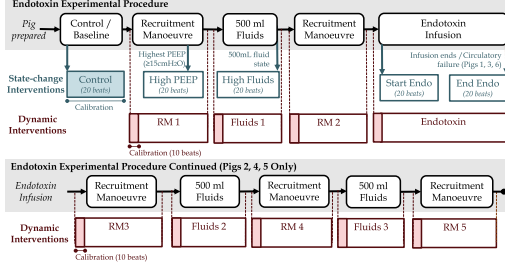


Fig. 1. The schedule of interventions performed on the examined pigs ([11])

B. Transfer function derived from the Tube Load model

The Tube load model describes the cardiovascular system as parallel lossless tubes with loads at the end of the tubes. In this study, a simple zero-pole model is used as the load, described with parameters A and B as follows:

$$Z_{load}(\omega) = Z_c \frac{j\omega + B}{j\omega + A}, \quad (1)$$

where $(0 < A < B)$ and Z_c are the impedance of the corresponding tube, ensuring pressure wave reflections are positive, stable, and become negligible at high frequencies. As the frequency becomes very large, the peripheral load tends to Z_c , and the tube and load are impedance matched, so there are no reflections. The model can be used to create transfer functions between central and peripheral pressures and flows in the frequency domain. Using the Laplace transform, the transfer function can also be represented in the continuous time domain:

$$\dot{P}_{ao,est}(t) + BP_{ao,est} = \dot{P}_{fem}(t + PTT) + \frac{B+A}{2}P_{fem}(t + PTT) + \frac{B-A}{2}P_{fem}(t - PTT), \quad (2)$$

where $P_{ao,est}$ is the estimated central arterial blood pressure, P_{fem} is the measured femoral arterial blood pressure, and PTT is the pulse transit time - the time it takes the blood flow to reach to the femoral arterial measurement site from the central arterial measurement site.

Equation (2) describes the transfer function with parameters A, B and PTT, the parameters that are identified by the NeuralODE-based identification method.

C. Deriving model parameters with physiological meaning

Using the Tube Load model, the reflection coefficient of the aorta (Γ) is given as:

$$\Gamma = \frac{Z_L(j\omega) - Z_c}{Z_L(j\omega) + Z_c}, \quad (3)$$

where Z_L is the frequency-dependent load impedance - also called input impedance -, Z_c is the characteristic impedance of the tube, and Γ is the reflection coefficient defining the ratio of reflected pressure (P_r) to forward travelling pressure (P_f) waves at point 0 (i.e. the point of reflection): $P_r(0, j\omega) = P_f(j\omega) \cdot \Gamma(j\omega)$. The details of the Tube Load model can be found in the PhD thesis of Liam Murphy [12].

The propagation of blood pressure waves can be expressed as the sum of forward travelling and reflected waves:

$$P_f(x, j\omega) = P_f(0, j\omega)e^{j\omega PTT \frac{x}{d}} \quad (4)$$

$$P_r(x, j\omega) = P_r(0, j\omega)e^{-j\omega PTT \frac{x}{d}} \quad (5)$$

$$P = P_f(0, j\omega)e^{j\omega PTT \frac{x}{d}} + P_r(0, j\omega)e^{-j\omega PTT \frac{x}{d}} = P_f(0, j\omega) \left[e^{j\omega PTT \frac{x}{d}} + \Gamma(j\omega)e^{-j\omega PTT \frac{x}{d}} \right], \quad (6)$$

where d is the length of the tube, x is the distance from the endpoint of the actual position in the tube, and $PTT \frac{x}{d} = t$.

The central arterial (aortic) and peripheral arterial blood pressures are the pressures at the beginning of the tube and at the point of reflection:

$$P_{ao}(j\omega) = P_f(0, j\omega) [e^{j\omega PTT} + \Gamma(j\omega)e^{-j\omega PTT}] \quad (7)$$

$$P_{fem}(j\omega) = P_f(0, j\omega) [1 + \Gamma(j\omega)] \quad (8)$$

$$\frac{P_{ao}}{P_{fem}} = \frac{e^{j\omega PTT} + \Gamma(j\omega)e^{-j\omega PTT}}{1 + \Gamma(j\omega)} \quad (9)$$

The frequency-dependent load impedance Z_L from Equation (3) can be described by a simple zero-pole model as seen in Equation (1). The equation yields the $0 < A < B$ constraint. The parameters must be positive so that the stability is assured, and the $A < B$ constraint assures that the impedance has a low-pass characteristic, which is a trait of the cardiovascular system, and so a physiological constraint.

Substituting Equation (1) in Equation (3), we get the reflection coefficient described with the A and B parameters:

$$\Gamma(j\omega) = \frac{Z_L(j\omega) - Z_c}{Z_L(j\omega) + Z_c} = \frac{B - A}{A + B + 2j\omega} = \frac{B - A}{2} \frac{1}{j\omega + \frac{B+A}{2}} = \frac{B - A}{B + A} \frac{1}{1 + \frac{j\omega}{\frac{B+A}{2}}}. \quad (10)$$

So the gain of the reflection coefficient is given as $\frac{B-A}{B+A}$, and $\frac{B+A}{2}$ is the cutoff frequency, as the reflection coefficient has a low-pass characteristic.

Combining Equations (9) and (10), we get Equation (11), which is the transfer function described with the A and B parameters in the frequency domain.

$$\frac{P_{ao}(j\omega)}{P_{fem}(j\omega)} = \frac{\left(\frac{A+B}{2} + j\omega\right) e^{j\omega PTT} + \frac{B-A}{2} e^{-j\omega PTT}}{B + j\omega}. \quad (11)$$

In our previous work [10], a benchmark test was conducted to assess the robustness of the developed parameter identification method. By solving Equation (2) with one specific parameter set ($A_x; B_x$) and a given femoral aortic pressure input, simulated central aortic pressure curves were created and used as an input of the parameter identification method instead of real measurements to examine the behaviour of only the identification method.

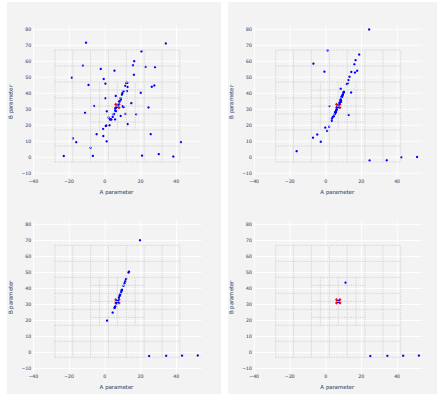


Fig. 2. The resulting parameter values after 4 (top left), 10 (top right), 20 (bottom left) and 40 (bottom right) training cycles during the benchmark test [10].

Figure 2 shows the changes of the A and B parameter values started from different initial values around the known optimal parameters ($A_x; B_x$) during the iterative optimization processes of the NeuralODE-based identification method. It can be seen in the Figure that the A and B parameters first converged to a line and then, following the line, moved to the known optimal parameters.

Examining Figure 2, there seems to be a linear relationship between the A and B parameters. The gain of the reflection coefficient described in 10 is proportional to the ratio of the two parameters mentioned above, so it could be used to describe the experienced linear relationship and, thus, be a better marker of the physiological state of the modelled blood vessels. Furthermore, physiological meaning can be associated with Γ , as well as the cutoff frequency ($\Theta = \frac{B+A}{2}$), which makes these better fit to describe physiological states during the different interventions on the subjects throughout the measurements.

Based on the Γ and Θ parameters, the A and B parameters can be exactly derived: $A = \Theta(1 - \Gamma)$, $B = \Theta(1 + \Gamma)$.

Using the inverse Laplace transform, Equation (9) can be converted to the time domain, and the differential equation

that is used during the parameter identification process can be obtained using Γ and Θ instead of A, B :

$$\dot{P}_{ao,est}(t) + \Theta(1 + \Gamma)P_{ao,est} = \dot{P}_{fem}(t + PTT) + \Theta P_{fem}(t + PTT) + \Theta \Gamma P_{fem}(t - PTT) \quad (12)$$

In summary, the model can be equally described with the parameter set A, B as with Γ, Θ . As the latter parameter set has better physiological interpretation, so using Γ, Θ would better serve the analysis of the physiological state changes, which is one of our main research goals. Thus, Γ, Θ will be used for the system analysis.

D. Alternative Pulse Transit Time acquisition methods

Pulse Transit Time (PTT) is the time it takes the blood pressure wave to travel from the central arterial measurement site to the peripheral (femoral) arterial measurement site. It can be directly calculated using central arterial and femoral arterial blood pressure measurements, as the time delay between the two waves' feet represents the systole's initial point in each measurement site.

Using the measured pressure waves and calculating PTT for each heartbeat, the Γ and Θ parameters can be identified as seen in Figure 3 in the case of *pig8 base* section. The sampling rate of the measurement was 250 [Hz], meaning that the time resolution of the measurement is 0.04 [s], resulting in ± 0.04 [s] measurement error on the PTT calculation. Comparing this measurement error with the absolute value of PTT, having its maximum value in a given time period around 0.12 (see the top subfigure in Figure 3), the estimated relative error of the PTT calculation due to the 250 [Hz] sampling frequency is around 33%. This means that the inaccuracy of the calculated PTT caused by the relatively high sampling time has to be assessed - especially considering its effect on the identified parameters.

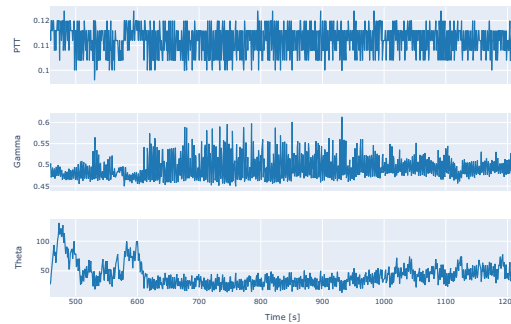


Fig. 3. The PTT calculated using the measurements (top), the identified *Gamma* and *Theta* parameters (middle and bottom) with relatively large variances likely due to the measurement noise caused inaccuracy of the calculated PTT parameter

Two alternative solutions are proposed and investigated to compensate the excessive noise caused by inaccurate PTT measurement:

- 1) Assuming that the PTT is a slowly changing physiological parameter that can be considered constant in a few subsequent heartbeats and the time sampling is asynchronous to the heartbeats, then applying a moving average on the calculated PTT values may be a way to compensate for the effect of measurement noise on the PTT.
- 2) Identifying PTT as a model parameter instead of calculating it based on measurement data.

Using a moving average to smooth the calculated PTT curve is an easy-to-implement solution and expectedly results in physiologically more accurate PTT values. Identifying the PTT as a model parameter has the potential advantage of better fitting simulated curves as this solution increases the order of freedom of the parameter identification by adding another parameter to be identified and minimising the curve fitting error.

III. RESULTS AND DISCUSSION

A. Alternative Pulse Transit Time acquisition methods

In Figure 4, the three ways of acquiring PTTs are shown in the case of the *pig8* *base* section: the curve showing the PTTs calculated directly from the measurements, the curve of the averaged PTTs using a 7 sample moving window, and the curve of the identified PTT values.



Fig. 4. PTT values calculated directly from the measurements (blue), the curve of the averaged PTTs (orange) using a 7 sample moving window, and the curve of the identified PTT values (green) and the corresponding Γ parameters

The identified PTT values shown in Figure 4 significantly differ from the calculated ones, which results in different identified Γ parameters as well. This trend is consistent in other measurement sections of the experiments. Our goal is

Name	Mean	Std	Perc25	Median	Perc75
base	0.489	0.012	0.481	0.489	0.497
rm1	4.848	11.284	0.491	0.554	0.889
pause1	0.445	0.012	0.439	0.445	0.451
fluid1	0.469	0.014	0.46	0.468	0.477
pause2	0.41	0.02	0.395	0.405	0.429
rm2	8.451	15.935	0.379	0.44	10.947
pause3	0.386	0.012	0.381	0.387	0.393
endotoxin1	0.434	0.042	0.412	0.421	0.435
endotoxin_pause	39.78	55.4	0.534	1.38	96.987
endotoxin2	14.203	34.78	0.455	0.475	1.278
fluid2	-5.848	4.313	-8.737	-5.988	-1.016

TABLE I
STATISTICAL PROPERTIES OF Γ IN DIFFERENT SECTIONS OF THE MEASUREMENT OF *pig8*

to examine the changes of physiological variable Γ through the different interventions. Thus, it is important that the Γ parameters are according to the subject's physiological state, which is ensured only if we do not identify but calculate the PTT values. However, using a moving average with a 7 sample window results in a smoother PTT curve and also in smoother identified Γ parameters. As a conclusion of these results the averaged PTT values are found beneficial for use in the parameter analysis studies.

B. A benchmark study: parameter analysis of *Pig 8*

The measurement of *pig 8* stopped soon after the endotoxin infusion. It started with a *base* sections, followed later by two *rm* sections, three *pause* sections, two *fluid* sections, and two *endotoxin* sections with a pause in between.

In the *base* section, the identified Γ values are consistently near 0.5, while Θ shows fluctuations. During this period, PTT values and the measured blood pressures are stable, as well as Γ . In the two *rm* sections, as the mechanical ventilation pressure rises, so does Γ , and Θ decreases to close to zero. In *pause1* and *fluid1* sections, Γ values are stable, with fluctuating identified Θ values. In *pause2*, Γ decreases gradually to 0.4. In the *pause3* section, the parameters are stable, however, in the second part of the *endotoxin1* intervention, the Γ values rise, and Θ decreases. By the end of *endotoxin1*, Γ goes to 0.65 from 0.4, and this trend continues in *endotoxin_pause* with extreme high Γ , and low Θ values. By the end of the pause, the Γ values stabilize in the physiologically correct range, however the second endotoxin infusion has the same effect as the first, and this leads to an extreme drop in blood pressure and the heart function stops.

To sum it up, in the sections from *base* until *endotoxin1*, the Γ parameters take on physiologically correct values (with occasional extreme spikes). In Figure 6, the boxplots of Γ in these sections are shown. On the y axis, logarithmic scale is used to enable the visualization of both the physiological range and *rm* sections. It is visible that *fluid1* resulted in a small increase of the Γ parameter.

Table I contains the descriptive statistics of the sections of the measurement of *pig 8*.



Fig. 5. The identified Γ and Θ parameters, the applied mechanical ventilation pressure (mvPw), and the arterial pressure (Pao) of pig 8

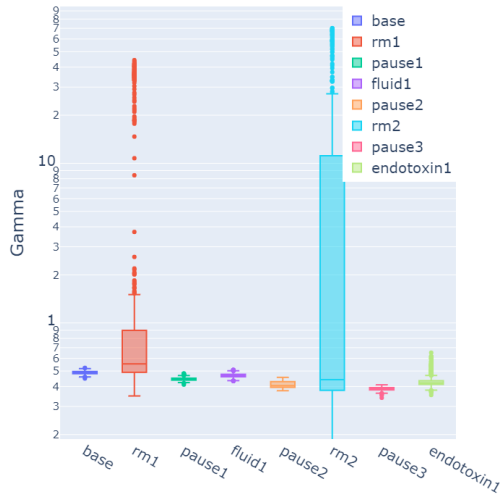


Fig. 6. The box plots of Γ parameters in sections of pig 8

IV. CONCLUSIONS

The NeuralODE-base parameter identification method is found to be efficient in the analysis of physiological-state-induced parameter changes of the artery. The physiological interpretation of the results became easier by using the

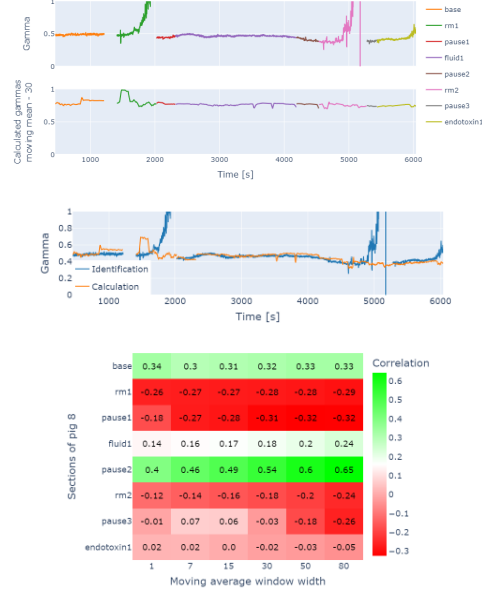


Fig. 7. The identified and calculated Γ values in different sections of pig 8 in separate axes (top), superimposed with the means adjusted (middle), and the correlation values between the identified Γ curve and the moving averaged calculated Γ curves with different (1, 7, 15, 30, 50, 80) sample wide windows (bottom).

proposed set of transfer function parameters, Γ and Θ . By the presented physiological analysis, the applicability of the proposed methodology is demonstrated. Using the methodology for the analysis of the available data sets will be a substantial help in improving our understanding of the effect of different clinical interventions and developing the model-based biological marker identification method, enabling better control of fluid therapy.

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SACI 2024 Preliminary Program

Venue: Conference Center, Politehnica University of Timisoara
Address: 2, Vasile Parvan Blvd., 300223 Timisoara, Romania

May 23, Thursday

9:00 – 9:20 Opening Ceremony Auditorium

9:20 – 9:55 Plenary Talk I Auditorium
Session chair: Imre J. Rudas

124	Hamido Fujita	Views on Artificial Intelligence and Machine Learning perspectives
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9:55 – 10:30 Plenary Talk II Auditorium
Session chair: Levente Kovács

128	Haibin Zhu	E-CARGO and Role-based Collaboration
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10:30 – 10:50 Coffee break

10:50 – 11:25 Plenary Talk III Auditorium
Session chair: Péter Galambos

101	Swaswati Purkayastha, Kandarpa Kumar Sarma and Nikos Mastorakis	Spread Spectrum Modulation Combined with AI in for Jamming Resistant Communication
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11:25 – 12:00 Plenary Talk IV

Auditorium

Session chair: Marius Marcu

129	Mihai Udrescu	Turning the tables in hybrid classical-quantum systems—classical optimization of quantum algorithms
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12:00 – 13:20 Lunch

Restorant Universitar (address: Aleea FC Ripensia no. 1)

13:20 – 14:40 [T1a] Special session on Nonlinear Mathematical Problems: Theory and Applications I

Auditorium

Session organizer and chair: Alexandru Kristály

103	Timea Melinda Személy Fülöp and Diana Ioana Borlea	Integral Characterizations of Uniform h-Dichotomy in Mean for Stochastic Skew-Evolution Semiflows
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Ana Şirianţu: Zabczyk type theorems for stability of variational systems - an ergodic theory approach

Dhivya Prabhu K: A third order iterative algorithm for inversion of cumulative central beta distribution

Árpád Baricz: Generalized gamma convolutions and modified Bessel distributions

13:20 – 14:40 [T1b] Session on Systems Engineering I

Room K1 Amphitheater

Session chair: Péter Kádár

70	Cezara-Liliana Rat, Octavian Prostean and Catalin Ichim-Burlacu	Simplified DC-DC converter models for interconnecting loads to a DC microgrid
31	Róbert Štefko and Marek Bobček	Artificial Intelligence and Energy Efficiency Revolution in Electric Consumption Management
65	Peter Kadar and István Bendiák	Laboratory Studies of Artificial Inertia
126	László Horváth	Multidisciplinary and Multiphysical Model Represents Complex Research in Applied Informatics

14:40 – 15:00 Coffee break

15:00 – 16:20 [T2a] Special session on Nonlinear Mathematical Problems: Theory and Applications II

Auditorium

Session organizer and chair: Alexandru Kristály

108	Ariana Gaina and Mihail Megan	On Uniform Dichotomy with Growth Rates of Skew-Evolution Cocycles in Banach Spaces
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Carmen-Florinela Popa: Discrete Characterizations of h-Dichotomy for Linear Discrete-Time Systems in Banach Spaces

Csaba Farkas: A fourth-order nonlinear eigenvalue problem with singular and sublinear potential

Alexandru Kristály: Clamped plates on curved spaces

15:00 – 16:20 [T2b] Special session on Digitalisation, Generation Research, Consumer Trends

Room K1 Amphitheater

Session organizers and chairs: Mónika Garai-Fodor, Ágnes Csiszárík-Kocsir and János Varga

2	Krisztian Balint	Comparison of the Consumer Blockchain (CB) and the Óbuda Ethereum Private Blockchain (ÓEPB) to Store Even More Secure Consumer Habits
33	Máté Prorok and István Takács	The Impacts of Artificial Intelligence and Knowledge-Based Systems on Corporate Decision Support
48	Kornelia Lazanyi	Exploring Social Dynamics in the Information Society
89	Rozalia Hanna Szatmary	Generational Differences in Online Behavior - Exploring Attitudes Towards Privacy, Trust, and Social Interaction

15:00 – 16:20 [T2c] E-poster session on Computational Intelligence and Systems Engineering

Room K2 Amphitheater

Session chair: Ladislav Főző

8	Hairong Chen, Qiaolin Zhang and István Bíró pending	A Comparative Analysis of Different Longitudinal Bending Stiffness Shoes on Running Biomechanics in Adolescent Amateur Runners
10	Qiaolin Zhang, Hairong Chen, Xinyan Jiang and Bíró István pending	Prediction and effectiveness verification of Chevron osteotomy surgical plan using finite element method
23	Xinyan Jiang, Qiaolin Zhang and István Bíró pending	Effects of long-distance running on lower limb joint kinematics in recreational runners
62	Rudolf Andoga, Ladislav Főző and Ján Vaščák	Fuzzy adaptive speed controller for a small turbojet engine
80	Dániel Kovács and Éva Hajnal	Current and Potential New Methods to Prevent Damage Caused by Wild Animals in Agricultural Areas

85	Ágnes Gerse, Adrienn Dineva and Rita Fleiner	The Impact of Spatial Distribution on Wind Power Availability: A Model-based Analysis for Hungary
98	Jozef Pavlinský, Peter Gašparovič, Ladislav Főző and Rudolf Andoga	Various wing end plates and their effect on the two-dimensionality of airflow
20	Monika Pogatsnik, Éva Beke and Rita Bodáné Kendrovics	Essential Teambuilding Skills For Project Work In Engineering Studies

16:20 – 18:00 [T3a] Session on Computational Intelligence I

Auditorium

Session chair: János Grantner

16	Vladik Kreinovich, Olga Kosheleva and Ahnaf Farhan	Fuzzy Ideas Explain Fechner Law and Help Detect Relation Between Objects in Video
28	Mohsen Mohaidat, Fatemeh Rashidi Fathabadi, Koloud N. Alkhamaiseh, Janos Grantner, Saad A. Shebrain and Ikhlas Abdel-Qader	A Systematic Approach to The Development of An Automated Assessment System for Laparoscopic Surgery Fundamentals
39	Alexandru M. Pescaru and Mihai V. Micea	Driving behavior extraction based on eyes movement patterns
112	Ildar Batyrshin and Imre Rudas	New Similarity Correlation Functions for Sets and Binary Data based on Jaccard Similarity Measure
18	Esra Çakir	Multi-Criteria Evaluation of Battery Electric Vehicles via Circular Intuitionistic Fuzzy PROMETHEE

16:20 – 18:00 [T3b] Session on Computational Intelligence II

Room K1 Amphitheater

Session chair: László Lindenmaier

26	Gábor Knyihár and Kristóf Csorba	Utilizing Transfer Learning in In Vitro Dissolution Prediction based on Raman Maps
52	George-Vlăduț Popescu, Mihai Antonescu, Alexandra-Mihaela Enescu and Teodor Mărgineanu	Evaluation of DarkNet19 and DarkNet53 Inference Time on CPU, GPU, and FPGA
13	Wei Liu, Kaiwen Li, Wenhua Li, Rui Wang and Tao Zhang	Multi-agent Deep Reinforcement Learning for Multi-modal Orienteering Problem
37	László Lindenmaier, Szilárd Aradi and István Ferenc Lövétei	Real-Time Rail Energy Consumption Minimization: Optimal Speed Profile Planning
81	Domonkos Csuzdi, Olivér Törő and Tamás Bécsi	Differentiable Particle Filtering using Optimal Placement Resampling

16:20 – 18:00 [T3c] E-poster Special session on Digitalisation, Generation Research, Consumer Trends

Room K2 Amphitheater

Session organizers and chairs: Mónika Garai-Fodor, Ágnes Csiszárik-Kocsir and János Varga

40	Lili Belkovics, Krisztina András and István Takács	Formula 1 - Information Solutions on and off the Racetrack
69	Mariann Bekesy, Laszló Gulacsi and Orsolya Szigeti	Cultural differences in attitudes towards robots - based on negative attitude towards robots (NARS) scale: Protocol for a systematic literature review
113	Csilla Mizser	Tasks related to whistleblower protection. Integrity and organization
114	János Kosztolányi and Zsolt Téglá	Lean Management Knowledge Survey in Hungary
117	Izabella Krájnik and Róbert Demeter	QR code applications digital literacy skills in today's technology-driven world in the field of education
118	Ágnes Csiszárik-Kocsir, István Márk Tóth and János Varga	Aspects of successful teamwork on the road to agility
119	János Varga and Ágnes Csiszárik-Kocsir	Small business digital solutions for competitive advantage in operations
120	Ágnes Csiszárik-Kocsir, Bernadett Revák and Serkan Savas	The use of artificial intelligence in learning on social networking sites among Hungarian and Turkish youth
121	Attila Balogh	The role of Top Management in Corporate Innovation Projects
122	Katalin Jaeckel and Monika Garai-Fodor	AI as viewed by Generation Z. Advantages, disadvantages and challenges of AI based on primary findings.

18:30 Welcome Reception

Restorant Universitar (address: Aleea FC Ripensia no. 1)

May 24, Friday

8:40 – 10:40 [F1a] Session on Informatics I

Auditorium

Session chair: Ryszard Klempous

27	Raul Brumar, Mihai-Alexandru Grosu, Stelian Nicola and Horia Ciocarlie	Streamlining Serious Game Development: An extensible system for unifying controls in cross-platform serious game development
63	Rajmund Drenyovszki and Zsolt Csaba Johanyák	Development of an Attack Detection Module for Vehicular Ad-hoc Networks
71	Oana Sorina Chirila, Denis Avram, Mihaela Monica Szilagyi, Ciprian-Bogdan Chirila and Lăcrămioara Stoicu-Tivadar	Enhancing Patient Care: Achieving Interoperability between General Practitioners' and Stomatologists' information systems using FHIR standard and Firebase cloud
130	Akihiro Yorita, Mario Radke, Matthias Rättsch and Naoyuki Kubota	Self-Categorization Theory with 3D Emotional Model for Chatbot Emotional Support Systems
84	Ciprian-Bogdan Chirila and Ioana Sora	Java single vs. platform vs. virtual threads runtime performance assessment in the context of key class detection
116	Marek Kulbacki, Zenon Chaczko, Sophie Barton, Peter Wajs-Chaczko, Jan Nikodem, Jerzy Rozenblit, Ryszard Klempous, Atsushi Ito and Michał Kulbacki	Weaponization of IoT

8:40 – 10:40 [F1b] Session on Informatics II

Room K1 Amphitheater

Session chair: Zoltán Rajnai

6	Awudu Atinga, Krisztián Krisztián Kósi and József K Tar	Improving the Tracking Precision of a Robust Sliding Mode Controller using Steffensen's Convergence Accelerator Strategy
30	Mario-Mihai Mateas and Cosmin Marsavina	Pie: A General-Purpose Code Editor Focused on Simplicity
22	Attila Nagy, Szilvia Ács, Anikó Horváth-Kiss, Beatrix Fregan and Zoltán Prof Dr. Rajnai	Machine Learning Used In Cyber Security
74	Toraş-Mihnea Jipianu and Iulian Aciobanitei	An implementation for secure data deduplication on end-to-end encrypted documents
51	Dorottya Mandic, Gabor Kiss and Zoltan Rajnai	Password usage among users of smart devices in Hungary and Serbia
127	Attila Biro	Gamification, GenAI and Reinforcement Learning as Motivational Assets in Performance Sports

8:40 – 10:40 [F1c] Session on Computational Intelligence III

Room K2 Amphitheater

Session chair: Dániel András Drexler

29	Krisztian Búza	Activity Recognition Based on Accelerometer Data with Enhanced ROCKET Algorithm
86	Vivien Roxána Patakvölgyi, Levente Kovács and Dániel András Drexler	Artificial neural networks based cell counting techniques using microscopic images: A review
42	Tamás Tompa and Szilveszter Kovács	Integrating Expert Knowledge into Fuzzy Reinforcement Learning
88	Lilla Kisbenedek, Melánia Puskás, Levente Kovács and Dániel András Drexler	Noise reduction with wavelet transform for clustering time series of tumor volumes

Bálint Varga: Toward Adaptive Cooperation: Model-based Shared Control Using LQ-Differential Games

92	Martin Ferenc Dömény, Melánia Puskás, Levente Kovács and Dániel András Drexler	A review of multi-objective optimization algorithms in the field of chemotherapy optimization
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10:40 – 11:00 Coffee break

11:00 – 13:00 [F2a] Session on Informatics III

Auditorium

Session chair: Bálint Varga

24	Daniel Ferenczi and Melinda Tóth	Safe process state upgrades through static analysis
53	Sára Szatmáry	Analysis of optimization task running results on D-Wave and IBM quantum computers
75	George Andronache and Iulian Aciobanitei	DAnke - An application for promoting a healthy lifestyle using gamification and blockchain
78	Márk Tamás Baross, András Németh, Balázs Gábor Szatmári, Tibor Ágoston and Péter János Varga	Implemented University practical course for 5G Stand Alone system with Augmented Reality
91	Judit Szucs and Tibor Guzsvinecz	A Preliminary Analysis of E-sports Game Reviews
76	Bianca-Daniela Ionaşcu and Iulian Aciobanitei	Enriching an Open-Source Access Management Platform using Multi-Factor Authentication

11:00 – 12:40 [F2b] Session on Systems Engineering II

Room K1 Amphitheater

Session chair: Zsolt Čonka

57	Marek Bobcek, Zsolt Čonka and Judith Palfi	Neural Network-Based Fault Learning using Artificial Intelligence and Kalman's Filter
102	Atlanta Choudhury, Kandarpa Kumar Sarma and Nikos Mastorakis	AI- based Text to Scene Generation as part of a Pandemic Compliant Infrastructure
54	Károly Tamás Dr. Beneda and Bendegúz Balázs Bánfi	Electronic Rotor Speed Control for a Sustainable Aviation Fuel Pump Test Bench
115	Mariann Váraljai, Enikő Nagy, Bálint Nagy, Zoltán Balogh and György Molnár	Mindset-Shaping Solutions with Innovative IT and PM technologies in Higher Education
79	Mhd Bashar Al Kazzaz and Károly Tamás Beneda	Implementing supplemental fuel system for testing sustainable aviation fuel on TKT-1 micro turbojet engine

11:00 – 12:00 [F2c] e-poster session on Informatics and Intelligent Robotics

Room K2 Amphitheater

Session chairs: Miklós Mezei, Tamás Nógrádi and Gábor Molnár

15	Sara Kishan Roodbari, Saeed Beheshtian, Hamzeh Ghorbani, Mohammadreza Azodinia and Mohammed Mudabbir	Machine Learning-Based Prediction of Gas Hydrates Phase Equilibrium in Porous Medium Leveraging Big Data
58	Sándor Szénási, Gábor Légrádi and Balázs Vígh	Machine Learning-Assisted Approach for Optimizing Step Size of Hill Climbing Algorithm
64	Jean Rosemond Dora, Hluchy Ladislav and Jean Rosemond Dora	Exploitation of Thick Client Application Vulnerabilities and a Synopsis of Mitigation
125	Ákos Antal, Bálint Szabó, Ákos Szlávecz, Katalin Kovács, J. Geoffrey Chase and Balázs Benyó	Applying NeuralODE-based Cardiovascular Model Identification for Experimental Data Analysis
123	Szava Bansaghi, Laszlo Gulacsi, Marta Pentek and Tamás Haidegger	Digital Medical Devices in Infection Prevention and Control

12:30 – 14:00 Lunch

Restorant Universitar (address: Aleea FC Ripensia no. 1)

14:20 – 16:00 [F3a] Session on Intelligent Mechatronics and Intelligent Robotics

Auditorium

Session chair: Enikő Nagy

77	Krish K. Raj, Jiuta Tamata, Litili Waisale, Mansour H. Assaf, Voicu Groza and Rahul R. Kumar	Enhancing Reliability in Induction Machines: A Focus on Stator Inter-Turn Fault Diagnosis
87	Zoltán Farkas, Viktor Vass and György Györök	Electric vehicle battery fault detection using statistical methods
17	Stefania-Mihaela Firiza, Alfred-Marius Scornea and Alexandru Topirceanu	Visualizing the COVID-19 Pandemic: Retrospective Insights and Implications for Public Health Strategies
25	Aleksandar Rodić and Jelena Kljajić	Motion Planning of Tree Fruit Robot Picker in Presence of Obstacles Using Heuristic Approach
46	Lucian Sosdean, Loredana Stanciu and Adriana Albu	Automatic System for Learning the Process of Solving Rubik's Cube

14:00 – 16:00 [F3b] Special Session on PhD Student Research in Applied Informatics and Numerical Mathematics I

Room K1 Amphitheater

Session organizer and chair: László Horváth

21	Massimo Stefanoni, Dominik Csík, Peter Sarcevic, Ákos Odry and József Tar	Adaptive Control Lyapunov Function-based Controller Using Fixed Point Iteration
43	Róbert Paulik, Miklós Kozlovsky and Béla Molnár	Tissue Block and Digital Slide Registration Method for Microscopic Samples
44	Árpád Varga, János Fricz and Zoltán Braun	Experiments with a One Parameter Computed Torque Position Control Method Using a PLC and a Simple Linear Actuator
50	Judit Sörfőző Szügyi, Edit Szügyi and Márta Takács	Evaluating the Use of ChatGPT by University and High School Students
59	Balázs Vígh and Sándor Szénási	Development of Smart Electromechanical Clock
61	Masoumeh Vali, Levente Kovacs and Amir Hossien Gandomi	A New Mutation Operator for Tabu Search Algorithm for Continuous Optimization
82	István Szűcs and József Kopják	NB-IoT based IoT gateway reference design for energy metering
95	Zoltan Varga and Ervin Racz	A Comprehensive Statistical Assessment of the Maximum Power Point of Dye-Sensitized Solar Cell

16:00 – 16:20 Coffee break

16:20 – 17:40 [F4a] Special session on 5G and Cybersecurity

Auditorium

Session organizers and chairs: Anna Bánáti and Miklós Kozlovsky

34	Norbert Sámson and Andrea Tick	Digital Defense: Investigating Human Aspects of Cybersecurity
36	Yuqing Guan and Andrea Tick	Literature Review on Security of Personal Information in Electronic Payments
60	Szandra Anna Laczi and Valéria Póser	Navigating Children's Cybersecurity Landscape: Understanding the impact of cyberbullying, online harassment and identity theft on children
109	Dániel László Hegedüs, Ádám Balogh, Máté Érsok, László Erdődi, Lajos Olcsák and Anna Bánáti	Beyond Static Defense: Dynamic Honeypots for Proactive Threat Engagement

Session organizer and chair: László Horváth

99	Robert Paulik, Miklós Kozlovsky and Béla Molnár	Signal Detection in Three-Dimensional Confocal Microscopy Images through Deep Learning
105	Csaba Potyok, Barbara Simon, Ádám Hartveg, Máté Siket, Lehel Dénes-Fazakas, György Eigner, Milán Balázs, Levente Kovács and László Szilágyi	Mobile application development for diabetes patient
106	Lehel Dénes-Fazakas, Győző Dénes Fazakas, György Eigner, Levente Kovács and László Szilágyi	Review of Reinforcement Learning-Based Control Algorithms in Artificial Pancreas Systems for Diabetes Mellitus Management
107	Miklos Nagy, Barbara Simon, László Szász, Máté Siket, Lehel Dénes-Fazakas, György Eigner, Patrik Péter Süli, Levente Kovacs and László Szilágyi	Web application development for diabetes patients
110	Wendler Márk and József Kopják	Mechanical Brush Commutation Motor Drive Solution for Higher Education
111	Gergely Sebestyén and József Kopják	Mapping IQRF Wireless Networks Using Relative Addressing Technique

18:00

Banquet

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Thank you for your contribution!

See you next year at SACI 2025!